METHODS OF MAKING ARTICLES HAVING TOUGHENED AND UNTOUGHENED REGIONS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is a Continuation-in-Part of application Ser. No. 11/736,319, filed Apr. 17, 2007, which is herein incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] Embodiments described herein generally relate to methods of making articles having toughened and untoughened regions. More particularly, embodiments herein generally describe methods of making articles from composite materials having toughened and untoughened regions.

BACKGROUND OF THE INVENTION

[0003] In gas turbine engines, such as aircraft engines, air is drawn into the front of the engine, compressed by a shaft-mounted compressor, and mixed with fuel in a combustor. The mixture is then burned and the hot exhaust gases are passed through a turbine mounted on the same shaft. The flow of combustion gas expands through the turbine, which in turn spins the shaft and provides power to the compressor. The hot exhaust gases are further expanded through nozzles at the back of the engine, generating powerful thrust, which drives the aircraft forward.

[0004] Because engines operate in a variety of conditions, foreign objects may sometimes undesirably enter the engine. More specifically, foreign objects, such as large birds, hailstones, sand and rain may be entrained in the inlet of the engine. As a result, these foreign objects may impact a fan blade and cause a portion of the impacted blade to be torn loose from the rotor, which is commonly known as fan blade out. The loose fan blade may then impact the interior of the fan casing at an impact zone, thereby causing a portion of the casing to bulge or deflect. This deformation of the casing may result in increased stresses along the entire circumference of the fan casing.

[0005] In recent years composite materials have become increasingly popular for use in a variety of aerospace applications because of their durability and relative light weight. Although composite materials can provide superior strength and weight properties, and can lessen the extent of damage to the fan casing during impacts such as blade outs, improvements can still be made.

[0006] Current containment technology, such as that used to manufacture fan casings, generally requires the use of a thicker casing design at high stress regions. More specifically, current fan casings are often made using a thick, monolithic hardwall design, which can help fragmentize a released fan blade and minimize the extent of damage. The energy generated by a released fan blade impacting a hardwall fan casing can be dissipated by any of several controlled failure mechanisms including resin microcracking, composite material ply delamination, and composite material ply failure.

[0007] All of the previously described energy dissipation mechanisms require the use of an untoughened resin to ensure controlled failure of the fan casing upon impact of the released fan blade. More particularly, an untoughened epoxy resin can be applied uniformly to the entire fan casing during resin application. After curing, the resulting composite material will have the previously described controlled failure mechanisms. However, areas away from impact zones, or non-impact zones, need to be stronger in order to maintain the integrity of the casing should an impact occur. Therefore, additional layers of untoughened composite material are often applied in non-impact zones in order to provide strength and toughness, as well as compensate for the lower strength of the untoughened material. These additional layers add undesired weight to the fan casing.

[0008] Accordingly, there remains a need for methods for manufacturing articles that can provide increased strength to the article in desired regions without increasing the overall weight of the article.

BRIEF DESCRIPTION OF THE INVENTION

[0009] Embodiments herein generally relate to methods of making an article having at least one toughened region and at least one untoughened region comprising providing a material, applying a toughening agent to a portion of the material, shaping the material to produce a preform, applying an untoughened resin to the preform, and curing the preform having the applied untoughened resin to produce the at least one toughened region and the at least one untoughened region wherein the toughened region comprises a toughened resin having a fracture toughness of at least about 1.0 MPa-$m^{1/2}$.

[0010] Embodiments herein also generally relate to methods of making an article having at least one toughened region and at least one untoughened region comprising providing a material, applying a toughening agent to a portion of the material, shaping the material to produce a preform, applying an untoughened resin to the preform, and curing the preform having the applied untoughened resin to produce the at least one toughened region and the at least one untoughened region wherein the toughened region corresponds to the portion of the material comprising the toughening agent, the composite material comprises a transition region between each toughened region and untoughened region, and the toughened region comprises a toughened resin having a fracture toughness of at least about 1.0 MPa-$m^{1/2}$.

[0011] Embodiments herein also generally relate to method of making a fan casing having at least one toughened region and at least one untoughened region comprising providing a material, applying a toughening agent to a portion of the material, shaping the material to produce a fan casing preform, applying an untoughened resin to the fan casing preform, and curing the fan casing preform having the applied untoughened resin to produce the at least one toughened region and the at least one untoughened region wherein the toughened region corresponds to the portion of the material comprising the toughening agent and wherein the toughened region comprises a toughened resin having a fracture toughness of at least about 1.0 MPa-$m^{1/2}$.

[0012] These and other features, aspects and advantages will become evident to those skilled in the art from the following disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] While the specification concludes with claims particularly pointing out and distinctly claiming the invention, it is believed that the embodiments set forth herein will be better understood from the following description in conjunction with the accompanying figures, in which like reference numerals identify like elements.